Freescale Technology Forum


July 2009

Industrial Human Interfaces:
LCD (Segment and Graphical) Basics and Roadmap Overview

Nathan Lee
Regional Segment Marketer
Monochrome, Cost-Effective Segment LCD Displays

- Simple I/O interface
- Inexpensive
- Customizable
- Power consumption is relatively low for comparable sizes
- Passive display

Color Graphic Displays

- Very flexible
- Wide range of screen sizes
- Custom HMI based on software
- Video capabilities
- OS- or RTOS-based design
- Active display
Segment LCD Control
Considerations for MCU with integrated segment driver

• Battery operated?
  - On-chip charge pump - allows LCD operation as battery voltage drops**
  - Flash write capability to lowest Vdd operation range **
  - Operate display in low-power modes?
    – Toggle display information without exiting low-power mode

• Minimize pin count = higher level of multiplexing **
  - x4 Multiplexing is common. Freescale has x8 multiplexing.

• Layout flexibility: BP/FP pin function defined in software to assist with board layout **

** Freescale 9S08 solutions have these features and low power consumption. Watch for many new devices from Freescale during the next two years.
# How Freescale Beats the LCD Design Challenge

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Freescale Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Too many pins</strong> required to drive many segments</td>
<td>1. <strong>Total of 8 backplanes</strong></td>
</tr>
<tr>
<td>52 pins required for 192 segments in 4x48 mode</td>
<td>32 pins required for 192 segments in 8x24 mode</td>
</tr>
<tr>
<td>44 pins required for 160 segments in 4x40 mode</td>
<td>28 pins required for 160 segments in 8x20 mode</td>
</tr>
<tr>
<td>29 pins required for 100 segments in 4x25 mode</td>
<td>17 pins required for 104 segments in 8x13 mode</td>
</tr>
</tbody>
</table>

| 2. **Blinking mode** takes power and resources | 2. **Low-power blinking mode** |
| • Competitor parts offer blinking mode by setting a bit in a register | • Does not need to wake up the controller, can be activated and the CPU can go to sleep, but the segments will remain blinking at the pre-set frequency |
| • Power consumption increased by microcontroller | • Alternate display features can be activated to display additional data (i.e., blink temperature and time) |
| • must exit stop mode, execute the code and then go back to sleep in every blinking period | |

| 3. **Layout is very complex** because the frontplanes (FPs) and backplanes (BPs) are fixed in pin-outs | 3. Frontplane and backplane re-assignments |
| • FPs and BPs are commonly distributed on all sides of the microcontroller | • FP and BP can be software selectable to be either FP or BP, making board layout an easier task and very flexible for changes |
| • Special device placement and layout must be performed to reduce electromagnetic interference (EMI) and shorten communication lines between the microcontroller and the LCD display | |
| • Result: complex layout, and time consuming | |

| 4. LCD glass requires many voltages, and voltage divider resistor ladders consume too much power | 4. **Internal charge pump** provides all voltages required to power up LCD glass |
| • Battery voltage drops over the time to the point where displays suffers degradation by not having the optimum voltage levels | • Internal software selectable regulated power supply that keeps constant voltage across LCD glass to avoid degradation |
| | • LL16 offers 4 bits resolution trim to adjust contrast control (Only for S08 and V1 cores) |
KEY FEATURE:
Up to 8 back panels means you can drive more segments with fewer pins

Redundancy to increase reliability
# Current and Future of LCD Segment Microcontrollers

<table>
<thead>
<tr>
<th></th>
<th>256K</th>
<th>128K</th>
<th>64K</th>
<th>36K</th>
<th>64K</th>
<th>32K</th>
<th>16K</th>
<th>16K</th>
<th>8K</th>
<th>4K</th>
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<tbody>
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<td><strong>3V, low-power, high-performance</strong></td>
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<td>Thermostat/Metering/Medical</td>
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<td><strong>3V, ultra-low-power</strong></td>
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<td>Portable Medical/T-stat/Metering</td>
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<td><strong>5V, Hi EMI/EMC</strong></td>
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<td>Appliance/Metering/Cluster</td>
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<td>S08LL16 8x16=128</td>
<td>S08LL16 8x24=192</td>
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<td></td>
<td>S08LG32 8x29=232</td>
<td>S08LG32 8x37=296</td>
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<td>RS08LA8 8x21=168</td>
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<td>RS08LE4 8x14=112</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>28Pin</th>
<th>48Pin</th>
<th>64Pin</th>
<th>80Pin</th>
<th>100Pin</th>
<th>144Pin</th>
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</tbody>
</table>

- **3V, low-power, high-performance**: Suitable for Thermostat/Metering/Medical applications.
- **3V, ultra-low-power**: Suitable for Portable Medical/T-stat/Metering applications.
- **5V, Hi EMI/EMC**: Suitable for Appliance/Metering/Cluster applications.

**Microcontrollers**:
- S08LE4
- S08LA8
- S08LG16
- S08LG32
- RS08
- RS08LA8
- S08LL8
- S08LL16

**Pin Configurations**:
- 28Pin
- 48Pin
- 64Pin
- 80Pin
- 100Pin
- 144Pin

- **NEW**: Indicates new or updated models.

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# Explore New Segment LCD Solutions

<table>
<thead>
<tr>
<th>Segment LCD Solutions</th>
<th>Key Features and Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>S08LL16/8</td>
<td>LL16/8 offers Freescale’s ultra-low-power technology at 1.8V with winning features, such as 20MHz CPU, flash reprogramming and ADC accuracy. Intended for low-power and portable applications, such as thermostats and blood glucose meters.</td>
</tr>
<tr>
<td>9RS08LA8</td>
<td>The LA8 is a cost-effective MCU that features 6-channel 10-bit ADC, analog comparator, internal charge pump and internal oscillator.</td>
</tr>
<tr>
<td>9RS08LE4</td>
<td>The LE4 has the RS08 core, which provides 8-channel 10-bit ADC in 28-pin SOIC package options for small appliances and meters.</td>
</tr>
<tr>
<td>S08LG32</td>
<td>The LG operates up to 5V with EMI performance for automotive and industrial spaces, specifically electronic metering and home appliances.</td>
</tr>
<tr>
<td><strong>Common Features</strong></td>
<td>LCD features which can drive large segment (8x mode) LCDs with fewer pins. FP or BP reassignment simplifies PCB layout and provides the opportunity to optimize designs for EMI performance.</td>
</tr>
</tbody>
</table>
## 9S08LL16

<table>
<thead>
<tr>
<th>LCD Driver</th>
<th>9S08LL16</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on 8 backplanes 8x24 = 192 segments</td>
<td>LVD</td>
<td>64 LQFP</td>
</tr>
<tr>
<td>Based on 4 backplanes 4x28 = 112 segments</td>
<td>KBI</td>
<td>48 QFN</td>
</tr>
<tr>
<td>S08 Core</td>
<td>COP</td>
<td></td>
</tr>
<tr>
<td>Dual Flash Array 8K =16K</td>
<td>SPI</td>
<td></td>
</tr>
<tr>
<td>2K RAM</td>
<td>Comparator</td>
<td></td>
</tr>
<tr>
<td>ICE + 08BDM</td>
<td>LCD Driver 8x24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x2-ch 16-bit Timer</td>
<td></td>
</tr>
</tbody>
</table>

### Voltage Range
- 1.8V to 3.6V

### Core
- 20 MHz CPU speed

### Features
- 8-ch keyboard interrupt
- Up to 38 GPIOs
- Up to 18 LCD pins mux with GPIO
- LVD (low voltage detect)
- Time-of-day module

### Internal Clock Source (ICS)
- FLL
- On-chip oscillator
- External crystal support
- 2% accuracy over full operating range

### Development Tools
- On-chip ICE and 08BDM
### Product Comparison: MC9S08LL16 vs TI MSP430

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Segments Configuration</th>
<th>TI MSP430F IDD</th>
<th>FSL S08LL16 IDD</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>No contrast control, low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>ALL ON</td>
<td>6uA</td>
<td>1.8uA</td>
<td>70%</td>
</tr>
<tr>
<td>No contrast control, low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>ALL OFF</td>
<td>5uA</td>
<td>1.2uA</td>
<td>76%</td>
</tr>
<tr>
<td>No contrast control, low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>EVERY OTHER SEG</td>
<td>5.4uA</td>
<td>1.8uA</td>
<td>67%</td>
</tr>
<tr>
<td>With contrast control (3.08V), low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>ALL ON</td>
<td>9.8uA</td>
<td>3.3uA</td>
<td>66%</td>
</tr>
<tr>
<td>With contrast control (3.08V), low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>ALL OFF</td>
<td>7.4uA</td>
<td>2.0uA</td>
<td>73%</td>
</tr>
<tr>
<td>With contrast control (3.08V), low-power mode, crystal oscillator enabled, 32Hz frame rate, 4x22</td>
<td>EVERY OTHER SEG</td>
<td>7.9uA</td>
<td>3.3uA</td>
<td>58%</td>
</tr>
</tbody>
</table>

The MC9S08LL16 beats MSP430FG4618/F2013 on power consumption with more than 70% improvement.

*Based on the same testing environment.*
Graphics and Video LCD Control
Graphic Display System Considerations

► Display Resolution
  • Screen size?
  • Resolution?
  • Color depth?
  • Memory requirements?

► Basic LCD System Design

► System Cost
  • Package type?
  • Power management?

► Video, Graphic Support
  • Frame rate?
  • 2D or 3D? Animation?
  • Availability of video CODECs?

► Operating System
  • Linux, WinCE, or RTOS?
Display Size

- Usually specified in “inches”
- Value cited is the diagonal dimension of the viewable screen area

### Screen Size vs. Application

<table>
<thead>
<tr>
<th>Screen Size</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8”</td>
<td>Cell Phones</td>
</tr>
<tr>
<td>2.4”</td>
<td></td>
</tr>
<tr>
<td>3.5”</td>
<td>PDAs or Smart Phones</td>
</tr>
<tr>
<td>4.3”</td>
<td></td>
</tr>
<tr>
<td>5.7”</td>
<td>Appliances, Picture Frames</td>
</tr>
<tr>
<td>7.0”</td>
<td></td>
</tr>
</tbody>
</table>
What is a Pixel?

► A pixel is a single point in a graphic image
  • Display consists of thousands (or millions) of pixels arranged in rows and columns

► Pixels are so close together, they appear as one
  • Number of bits used to represent each pixel determines how many colors or shades of grey can be represented
    • B&W (black and white) each pixel is 1 bit
    • 8 bits per pixel allows 256 shades of grey or 256 colors

► For color displays, there are three pixels, one of each red, green & blue but referred to as a single pixel
Resolution

- Resolution is the number of pixels on the display.

- Usually described as $r \times c$:
  - $r$ is the number of pixels across the screen.
  - $c$ is the number of pixels down the screen.

- Typical resolutions range from:
  - 320 x 240 (QVGA)
  - 2560 x 2048 (QSXGA)
► Aspect ratio is the ratio of the width to height

► VGA [640x480], aspect ratio is 640:480 or 4:3

► WVGA [854x480], aspect ratio is 854:480 or 16:9

Landscape - The width is greater than the height

Portrait - The height is greater than the width
“Color depth or bit depth, is a computer graphics term describing the number of bits used to represent the color of a single pixel in a bitmapped image or video frame buffer. This concept is also known as bits per pixel (bpp), particularly when specified along with the number of bits used. Higher color depth gives a broader range of distinct colors.” Wikipedia – Color Depth
LCD Memory Requirements

Memory Size

- The panel size and bits per pixel determine the amount of memory needed to hold the graphic buffer.
- In some cases, twice as much memory (or more might be needed). It is typical to use one graphic buffer to store the current image while a second buffer containing the next image is prepared.

<table>
<thead>
<tr>
<th>Panel Resolution</th>
<th>Total Pixels</th>
<th>bpp (MemoryPP)</th>
<th>Required Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>320x240 (QVGA)</td>
<td>76.8K</td>
<td>18bpp (32bpp)</td>
<td>307.2KB</td>
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<tr>
<td></td>
<td></td>
<td>16/12bpp (16bpp)</td>
<td>153.6KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8bpp (8bpp)</td>
<td>76.8KB</td>
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<tr>
<td></td>
<td></td>
<td>4bpp (4bpp)</td>
<td>38.4KB</td>
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<tr>
<td></td>
<td></td>
<td>2bpp (2bpp)</td>
<td>19.2KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1bpp (1bpp)</td>
<td>9.6KB</td>
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</tbody>
</table>

Data frame buffer = (bpp * H * V) / 8

where:
- bpp = bits per pixel (color depth)
- H = viewable horizontal pixels
- V = viewable vertical pixels
Basic Architecture of Graphics System

- **CPU**
- **System memory**
- **Frame buffer**
- **Display Controller**
- **System Bus**
- **Monitor/ LCD**

**Graphics Hardware**
- Area of memory used for frame buffer
- Direct connection to video controller

**Frame Buffer**
- Cartesian coordinates
Intelligent Chip on Glass Graphical LCD Application

► System components
  • Standard 8-, 16- or 32-bit MCU

► Advantages
  • Quick and easy to implement
  • Can use any standard MCU

► Disadvantages
  • Can perform only limited animation
  • LCD panel sizes limited to 1/4 VGA maximum (at time of writing)
  • Graphic images limited by MCU flash size

► System cost (excluding LCD)
  • < $5

► SPI LCD Driven
  • Can be driven from any MCU

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Traditional Multi-chip Graphical LCD Application

System Components:
• MPU
• External flash
• External RAM
• External Ethernet & USB
• external graphics controller IC

Advantages
• Ability to support large displays
• Support for complex o/s, eg Linux

Disadvantages
• Cost
• Insecurity of memory supply
• External bus bandwidth
• Remaining processor capacity
• Package size and assembly costs

System cost (excluding LCD)
• > $25

Traditional LCD Driver
• Requires a dedicated LCD controller
Multi-chip MPU with Integrated LCD Controller

- System Components:
  - MPU
  - External flash
  - External RAM
  - External Ethernet & USB

- Advantages
  - Ability to support large displays
  - Support for complex O/S, eg Linux
  - Internal graphics controller IC

- Disadvantages
  - Cost
  - External bus bandwidth
  - Remaining processor capacity
  - Package size & assembly costs

- System cost (excluding LCD)
  - > $20

- Traditional LCD Driver
  - Requires a dedicated LCD controller
Smart vs Dumb LCD Panels and Bus Requirements

Dumb LCD TFT panels are very much like DRAMs
- No on-board frame buffer or graphics engine.
- Each cell is addressed by a row and a column.
- Each cell is capacitive in nature
- Cells need to be refreshed periodically
- Refreshing uses a lot of bus bandwidth

Smart LCD TFT panels – like static RAM
- Have on-board frame buffers and sometimes graphic engines.
- LCD is refreshed from on-board (LCD) RAM (frame buffer).
- CPU bus bandwidth is only used when data must be changed on display.
- Requires significantly less CPU bus bandwidth (even with video)
- Interface vis 68K or 80 series bus interface

Display system performance often comes down to bus bandwidth!!
Other System Cost Factors

► Packaging of the device
  • Is there an LQFP option?
  • What is the ball pitch on the BGA packages?
  • Can the assembly house handle the package requirements?

► Memory support
  • Does the device have internal RAM?
  • What types of memory are supported? DDR2, DDR3, etc?
  • What options are available for large data storage memory?

► System design
  • Do you have experience laying out high-speed data buses?
  • Multi-layer boards?
  • Do you need a power management device for this processor?

► Display interface
  • What display interface are you planning to use? RGB, LVDS, or RSDS?
  • You may want to consider VGA, DVI, HDMI, or display port…
Video Overview

What are the key parameters to consider when thinking about adding video capabilities to an embedded system?

► Frame rate (fps – frames per second)
  • Frame rate is the number of screens displayed in a given time period
  • Standard TV video approximately 30 fps

► Hardware support
  • System must be able to decode video file and load the frame buffer
  • Some solutions have hardware to assist with video decoding
  • Storage size and memory transfer speeds must also be considered

► Software support
  • Codec support is referred to as middleware and is separated from the O/S
  • H.264 is a common video compression for embedded products
Vector Graphics Overview

Vector Graphics is the use of primitives (points, lines, curves) based on equations to represent an image

► It is standard for graphics applications such as Adobe Flash and SVG (Scalable Vector Graphics)

► Advantage: Scalability
  • Vector Graphics provide easy scalability including:
    ▪ High-quality rendering
    ▪ Included anti-aliasing
  • Multiple screen size support without multiple bit maps
    ▪ Great for navigation applications

► 2D vs 3D
  • Today’s popular applications (iPhone) are 2D graphics
  • 2D graphics accelerators can provide 3D look and feel
  • 3D accelerators offer shading and depth
OpenVG vs OpenGL ES

OpenVG
Accurately represents SHAPE and COLOR

OpenGL ES
Accurately represents PERSPECTIVE and LIGHTING
High-end user interfaces require both OpenGL and OpenVG
A codec is a device or computer program capable of encoding and/or decoding a digital data stream or signal.

### Video Codecs
- H.264 encode / decode
- MPEG-2 MP decoder
- MPEG-4 SP/H.263 P3 decoder
- MPEG-4 SP/H.263 P3 encoder (GStreamer wrapper for hardware-accelerated codec)
- WMV9 SP/MP decoder
- MJPEG encode

### Audio Codecs
- AAC decode
- Enhanced aacPlus decode
- MP3 encode / decode
- WMA10 decode

### Image Codecs
- PNG
- JPEG
- BMP
- GIF

### Audio/Video Parsers
- ASF (WMA + WMV) demuxer
- AVI (H.264/MPEG-4 + MP3) demuxer
- M2V (MPEG-2 video) demuxer
- M4A (MPEG-4 audio) demuxer
- M4V (MPEG-4 video) demuxer
- MP4 (H.264/MPEG-4 + AAC/MP3) demuxer

Visit [www.freescale.com/imxcodecs](http://www.freescale.com/imxcodecs) for more information.

Support for Power Architecture® products can be found on freescale.com product pages.
<table>
<thead>
<tr>
<th>Development Tools: Demo CD and listing of 3rd party dev tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications: From demo applications to full turnkey solutions</td>
</tr>
<tr>
<td>Middleware: Media players/plug-ins, DRM, a/v codecs, audio post processing, connectivity and wireless stacks</td>
</tr>
<tr>
<td>BSP: Drivers and tool chains for Linux. Third-party O/S support for WinCE, QNX Neutrino, Green Hills Velocity, MQX, etc.</td>
</tr>
</tbody>
</table>

Please note that third-party support varies across the product families. For more details, please refer to the product summary pages on freescale.com.
Worldwide Community of Partners Providing Tools / Support
Driving Integrated Solutions on Freescale Platforms.
Freescale Graphics Enabled Processors
Freescale MCU/MPU Options with LCD

► Family based on ColdFire® architecture
  • Linux, RTOS options
  • $6-$14, QFP & BGA package options
  • Up to 240 MHz, USB, Ethernet, CAN, 12-bit A/D with touch control option
  • Up to SVGA (800x600), < 0.5W

► i.MX family based on ARM® architecture
  • WinCE, Linux, RTOS options
  • $7 - $25, LQFP & BGA package options
  • Up to 532 MHz CPU w/ various hardware acceleration blocks
  • 2D/3D, video codecs (MPEG4, H.264, etc)
  • Up to WXGA (1280x768), < 1.5W

► Family based on Power Architecture®
  • Linux, RTOS options
  • $10 - $20 and $75 for the very high end
  • 400 MHz, 1.33 GHz, 2D/3D hardware acceleration
  • Up to WXGA (1280x768), WUXGA (1920x1200), < 1.5W – 2W, <15W
Freescale Graphical LCD Portfolio

- >400 MHz
- Up to SXGA
- Graphics and/or video acceleration
- D1 – HD video
- 2.5 or 3D graphics
- Video CODECs

- >260 MHz
- Up to SVGA
- Video acceleration
- D1 video
- Video playback
- Video CODECs

- >160 MHz
- Up to SVGA
- On-board SRAM

MCF8610
MPC5121e/23
i.MX31x
i.MX51x
i.MX35x
MPC51xx
i.MX27x
i.MX25x
i.MX23x
MCF532x
MCF5227x

Power Architecture®
ARM®
ColdFire®

2009
The ColdFire® MCF5227x family provides an easy way to add support for graphical LCD interfaces to systems.

SVGA LCD and touch screen controller integration simplifies the system and reduces cost.

128K of integrated SRAM enhances overall application performance, lessens frequent access to external memories.

Integrating USB and CAN modules gives the ability to upgrade or standardize serial communications.

USB OTG enables host or device capability, allowing for mass storage device downloads and uploads.

Serial boot flash, flexible external bus and on-chip touch screen controllers reduce overall system cost.

Flexible external bus enables lower cost external memory (e.g. DDR, flash) and FPGA configurations.

M52277EVB Full Evaluation Platform
V2 ColdFire 160MHz
Available packages: 176QFP and 196BGA
Pricing starting at $5.99 10K suggested resale
i.MX233 Applications Processor

Key Features and Advantages

- 454-480MHz ARM926EJ-S core
- LCD Parameters
- PMU with high-efficiency on-chip DC/DC with 4.2V output, supports Li-Ion batteries
- Very low video and audio power consumption
- 1.5W mono speaker amplifier
- Stereo headphone DAC w/ 99dB SNR & stereo ADC w/ 85 dB SNR with integrated amplifiers
- NAND support – SLC/MLC and managed
- Hardware BCH (up to 20-bit correction) and RS ECC8 for current and future MLC NAND support
- DDR1 support with integrated 2.5V regulator
- High-speed USB with embedded PHY

Package and Temperature

- 169fpBGA 11x11mm .8mm
- 128LQFP 14x14mm*
- -10 to +70C (Consumer)
- -40C to +85C (Industrial)

Availability:

- Samples: Alpha Q109, Beta Q209
- Production: Q309 BGA, *LQFP TBD
Key Features and Advantages

- 400MHz ARM926EJ-S core
- SVGA, 262k colors
- 10/100 Ethernet MAC with RMII support
- Two on-chip USB ports with PHY
  - High-speed USB OTG with HS PHY
  - High-speed USB Host with FS PHY
- 128KB on-chip SRAM for low power LCD refresh
- 3 general purpose 12-bit ADC channels
- Touch screen controller
- Two CAN interfaces
- Two smartcard interfaces
- Enhanced serial audio interface
- External memory interface:
  - 133 MHz 16-bit 1.8V mobile DDR and DDR2
  - 133 MHz 16-bit 3.3V SDRAM
  - 8/16-bit NAND or NOR
- 3.3V I/O reduces external component count
- Enhanced security features, including tamper detection for voltage, frequency and temperature
- High-Assurance Boot (HAB)

Available Parts
- i.MX251, i.MX255, i.MX253, i.MX257, i.MX258

Package and Temperature
- 0.8mm, 400-pin MAPBGA
- -40C to +85C, -20C to +70C

Availability
- Alpha/Beta samples: Now
- General availability: 6/22/2009
i.MX35 Applications Processor

**Specifications**
- **CPU:** ARM1136JF-S, 400/532 MHz
- **Process:** CMOS90LP
- **Core Voltage:** 1.22-1.47V@400MHz, -40/85C, TBD@532 MHz
- **Package:** 400 ball 0.8mm BGA

**i.MX35 Value Proposition**
- **24-bit interface to WVGA (800 x 480) TFT displays**
- **IPU - Image Processing Unit**
  - Supports mirroring, rotation, image combining (2 planes), color space conversion.
- **OpenVG vector graphics processor (i.MX356)**
- Enhanced audio peripherals – multi-channel audio, S/PDIF, sample rate conversion
- **Flexible memory support**
  - SDRAM 16/32 bit, 133 MHz
  - DDR2 16/32 bit, 266MHz
  - SLC/MLC NAND
- **Connectivity enhancements**
  - CAN (x2) and MLB (MOST)
  - USB PHY integration
  - 10/100 Ethernet

---

**System Control**
- JTAG, ETM
- Bootstrap
- System Reset
- PLL & Power Mgmt

**i.MX356**
- **CPU Complex**
  - ARM1136 CPU
  - Smart Speed Switch (MAX)
  - 16KB i-cache
  - 16KB d-cache
  - 128KB L2-cache
  - 32KB Boot ROM
  - 2KB Secure RAM
- **Vector Floating Point Unit**
- **Multimedia & Human Interface**
  - 8x8 Keypad
  - ASRC
  - OpenVG 1.1 2.5D Accel.
  - Image Processing Unit Inversion and Rotation
  - Pre & Post Processing
  - Camera I/F
  - Blending
  - Display Ctrl

**External Memory**
- SDRAM
- mSDRAM
- mDDR
- DDR2
- NOR SLC NAND
- MLC NAND

**Special Functions**
- Security HW

**Standard System I/O**
- sDMA
- 3 x Timers
- PWM
- WD Timer
- RTC
- GPIO

**Connectivity**
- 2 x CSPI
- 2 x SSI/I²S
- 3 x UART
- 3 x PC
- USB HS Host FS-PHY or ULPI
- USB HS OTG w/ HS-PHY
- S/PDIF I/O
- 2 x FlexCAN
- 2 x SDIO/MMC
- Ethernet
- MLB
- 1-Wire
- CE-ATA

Inherited from i.MX31  New or enhanced from i.MX31
### Specifications:
- **CPU:** Cortex A8, up to 1GHz
- **Process:** 65nm, LP/GP
- **Core Voltage:** 0.7-1.1V
- **Package:** 13x13 0.5mm, 19x19 0.8mm
- **Temp Range:** -20 to 85°C, -40 to 85°C

### Key i.MX515 Features and Advantages
- High-performance CPU: Cortex A8
- Low-power multimedia
- **Delivers rich graphics and UI in HW**
  - OpenGL ES 2.0 3D accelerator (AMD Z430)
  - OpenVG 1.1 graphics accelerator (AMD Z160)
  - Neon Vector floating point co-processor
  - Display up to WXGA
- **Drives high resolution video in HW**
  - Multi-format D1 video encode
  - Multi-format HD720 video decode
  - Up to WXGA display - 24 bit @ 60fps
- Secondary display support
- Mixed-signal integration - HD720 TV out and high-speed USB with embedded PHY

### Availability:
- **Sample:** Now / 3Q 2008 (Auto)
- **Production:** 2Q 2009/ 3Q 2009 (Auto)
High-performance Power Architecture solution at a cost-effective/power-efficient point, which includes an MMU to enable full O/S (Linux) support.

- **Display / processing support**
  - Display interface supporting WXGA / 720p, 24-bit color
  - Network / audio acceleration, DSP-C programmable
  - OpenGL / OpenVG graphics acceleration (MPC5121e)
  - ITU-656 video input

- **Rich set of connectivity**
  - 12x flexible PSC (SPI, UART, AC’97, I²S, Multi-Ch TDM)
  - 4x CAN2.0 A/B, supports data rates in excess of 1Mbs

- **Cost-effective / low-power memory system support**
  - Bootable NAND flash interface
    - ECC corrects up to 4 errors (MLC support)
    - Fully pipelined ECC operating at NAND speeds
  - Bootable interface
  - DRAM interface (high-bandwidth, low-latency)
    - 32/16-bit DDR2 support (low-cost)
    - 32/16-bit MobileDDR support (low-power)

- **Low power**
  - Total system power is typically <2W @400MHz
  - Hibernation power down mode <25uW

- **800 Dhrystone 2.1 MIPS @ 400 MHz**
- **Packages:** 324 PBGA, 27x27mm, 1mm pitch
- **Price:** sub-$23/22 @ 10k qty
- **Sampling now, production ramp April 2009**
- **ADS512101 development board $999**
- **MPlus5121 development platform $3495**
- **3rd party boards listed on MPC5121e webpage**
**MPC8610 Block Diagram and Features**

**Integrated Host Processor**

**e600 Power Architecture™ CPU**
- 667 MHz – 1.33 GHz e600 core
- 256 KB on-chip backside L2 Cache with ECC
- AltiVec® vector processor for image processing
- Double precision FPU, 4 x integer units

**Interfaces and Features**
- DDR/DDR2 controller, 64/32-bit, 333-533 MHz (ECC)
- LCD controller, 24 bit/pixel, 60 Hz refresh
  - Up to SXGA (1280 x 1024) resolution
  - 3 planes (XGA) + 1 cursor plane
- 2-I²S/AC97 audio ports
- 2-PCI-Express® (x1/x2/x4/x8; x1/x2/x4)
- PCI 2.2, 32-bit, 33/66 MHz
- Enhanced local bus, 32-bit, to 133 MHz (ROM, NAND, NOR)
- 2-I²C, 2-DUART, 4 channels each, 115 kb/s
- 2- Fast/Serial IrDA channels, 4 Mb/s
- 2-DMA, 4 channels each
- Serial peripheral interface (SPI), 4 to 16/32-bit characters
- 32-GPIO, 16 dedicated, 16 multiplexed
- Machine check external interrupt
- Watchdog and 2-global timers

[freescale.com/imageprocessor](http://freescale.com/imageprocessor)

**Power, Package, Technology, Schedule**
- 15 W max at 1066 MHz, Tj=105°C, 0.95V
- 11.5 W max at 667 MHz, Tj=105°C, 0.95V
- **Package:** 783 FCPBGA
- **Production:** Now
Freescale Introduces Product Longevity Program

► The embedded market needs long-term product support, which allows OEMs to provide assurance to their customers.
► Freescale has a longstanding track record of providing long-term production support for our products.
► Freescale is pleased to introduce a formal product longevity program for the market segments we serve.
  • For the automotive and medical segments, Freescale will manufacture select devices for a minimum period of 15 years.
  • For all other market segments in which Freescale participates, Freescale will manufacture select devices for a minimum period of 10 years.
► A list of applicable Freescale products is available at www.freescale.com.
Thank you for attending this presentation.
We’ll now take a few moments to review the audience questions, and then we’ll begin the question and answer session.
**Integrated LCD driver**

LCD peripheral generates the FP and BP signals necessary to drive the display

**LCD glass module with SPI interface**

MCU generates the communication protocol necessary to interface to a smart LCD display

Flexible, but higher costs with limited features.

**L family consists of MCUs with integrated LCD driver that is used to LCD glass**
Using Blink Mode

Benefits of using blink mode

1- Blinking to a blank screen turns all segments off, leading to lower standby current for the time that the screen is blank.

2 - Using the alternate blink mode allows the application to remain in Stop mode for longer periods of time. Example: Using alternate display to show time across 2 seconds.
### LCD Memory Requirements (continued)

<table>
<thead>
<tr>
<th>Panel Resolution</th>
<th>Pixels</th>
<th>BPP (MemoryPP)</th>
<th>Required Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>640x480 (VGA)</td>
<td>307.2K</td>
<td>18bpp (32bpp)</td>
<td>1228.8KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16/12bpp (16bpp)</td>
<td>614.4KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8bpp (8bpp)</td>
<td>307.2KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4bpp (4bpp)</td>
<td>153.6KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2bpp (2bpp)</td>
<td>76.8KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1bpp (1bpp)</td>
<td>38.4KB</td>
</tr>
<tr>
<td>800x600 (SVGA)</td>
<td>480K</td>
<td>18bpp (32bpp)</td>
<td>1920KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16/12bpp (16bpp)</td>
<td>960KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8bpp (8bpp)</td>
<td>480KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4bpp (4bpp)</td>
<td>240KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2bpp (2bpp)</td>
<td>120KB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1bpp (1bpp)</td>
<td>60KB</td>
</tr>
</tbody>
</table>

Data frame buffer = (bpp * H * V) / 8  
where:  bpp = bits per pixel (colour depth)  
H - viewable Horizontal pixels  
V - viewable Vertical pixels
## LCD Memory Bandwidth (MB/s)

<table>
<thead>
<tr>
<th>Screen resolution</th>
<th>8-bit 50Hz</th>
<th>16-bit 50Hz</th>
<th>8-bit 60Hz</th>
<th>16-bit 60Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVGA</td>
<td>22.9</td>
<td>45.8</td>
<td>27.5</td>
<td>54.9</td>
</tr>
<tr>
<td>VGA</td>
<td>14.6</td>
<td>29.3</td>
<td>17.6</td>
<td>35.2</td>
</tr>
<tr>
<td>HVGA</td>
<td>7.3</td>
<td>14.6</td>
<td>8.8</td>
<td>17.6</td>
</tr>
<tr>
<td>QVGA</td>
<td>3.7</td>
<td>7.3</td>
<td>4.4</td>
<td>8.8</td>
</tr>
</tbody>
</table>

**Screen refresh rate of 50Hz or 60Hz**

- **High quality screen**
- **BUT**
- **High system/memory loading**

<table>
<thead>
<tr>
<th>Screen Resolution</th>
<th>8-bit 10Hz</th>
<th>16-bit 10Hz</th>
<th>8-bit 20Hz</th>
<th>16-bit 20Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVGA</td>
<td>4.6</td>
<td>9.2</td>
<td>9.2</td>
<td>18.3</td>
</tr>
<tr>
<td>VGA</td>
<td>2.9</td>
<td>5.9</td>
<td>5.9</td>
<td>11.7</td>
</tr>
<tr>
<td>HVGA</td>
<td>1.5</td>
<td>2.9</td>
<td>2.9</td>
<td>5.9</td>
</tr>
<tr>
<td>QVGA</td>
<td>0.7</td>
<td>1.5</td>
<td>1.5</td>
<td>2.9</td>
</tr>
</tbody>
</table>

**Refresh rate of 10Hz or 20Hz**

- **Significantly reduces loading**
- **BUT**
- **Screen quality / flicker issues**
### LCD Data Bus Mapping

#### Table 30-4. TFT Color Channel Assignments

|       | LD 17 | LD 16 | LD 15 | LD 14 | LD 13 | LD 12 | LD 11 | LD 10 | LD 9  | LD 8  | LD 7  | LD 6  | LD 5  | LD 4  | LD 3  | LD 2  | LD 1  | LD 0  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 4 bpp | R5    | R4    | R3    | R2    | R1    | R0    | G5    | G4    | G3    | G2    | G1    | G0    | B5    | B4    | B3    | B2    | B1    | B0    |
| 8 bpp | R5    | R4    | R3    | R2    | R1    | R0    | G5    | G4    | G3    | G2    | G1    | G0    | B5    | B4    | B3    | B2    | B1    | B0    |
| 12 bpp| R3    | R2    | R1    | R0    | –     | –     | G3    | G2    | G1    | G0    | –     | –     | B3    | B2    | B1    | B0    | –     | –     |
| 16 bpp| R4    | R3    | R2    | R1    | R0    | –     | G5    | G4    | G3    | G2    | G1    | G0    | B4    | B3    | B2    | B1    | B0    | –     |
| 18 bpp| R5    | R4    | R3    | R2    | R1    | R0    | G5    | G4    | G3    | G2    | G1    | G0    | B5    | B4    | B3    | B2    | B1    | B0    |

**RGB656**

**RGB666**

*Pixel 1  Pixel 2  Pixel 3  Pixel 4  Pixel N*
# Color Depth

<table>
<thead>
<tr>
<th>Color Depth</th>
<th>R</th>
<th>G</th>
<th>B</th>
<th># of Colors</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Bit</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>Monochrome</td>
</tr>
<tr>
<td>4-Bit</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>16</td>
<td>Plus one bit for intensity</td>
</tr>
<tr>
<td>8-Bit</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>256</td>
<td>Baseline for graphics</td>
</tr>
<tr>
<td>12-Bit</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4,096</td>
<td>Commonly used in cell phones</td>
</tr>
<tr>
<td>16-Bit</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>65,536</td>
<td>High Color</td>
</tr>
<tr>
<td>18-Bit</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>262,144</td>
<td>Most common in LCDs</td>
</tr>
<tr>
<td>24-Bit</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>16,777,216</td>
<td>True Color</td>
</tr>
</tbody>
</table>
### How many colors are needed?

<table>
<thead>
<tr>
<th>Shades</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 shades</td>
<td>Very noticeable edges where shade changes</td>
</tr>
<tr>
<td>32 shades</td>
<td>Slightly noticeable edges where shade changes</td>
</tr>
<tr>
<td>256 shades</td>
<td>No visible edges where shade changes</td>
</tr>
</tbody>
</table>

### How many shades of color are necessary?

- **32 shades**: Highest 16 intensity shades from pallet of 32.
Common Graphics APIs

**OpenGL ES**
- OpenGL (Open Graphics Library) is a standard specification defining a cross-language, cross-platform API for writing applications that produce 2D and 3D computer graphics.
- Full 3D API meant for 3D content such as games and some UIs. Version 1.1 is fixed-function, version 2.0 is fully programmable shader model

**OpenVG**
- OpenVG is a royalty-free, cross-platform standard API designed for hardware-accelerated 2D vector graphics. OpenVG is well suited to accelerating Flash or SVG sequences.
- Vector graphics API designed for User Interfaces, Navigation, animations and Flash content. Fully capable of compelling 3D UI effects

OpenVG brings high-quality UIs to mass-market
UI with Vector Graphics

- Video decoded with SW codec. Composition/windowing through composition API or frontend/backend composition
- Support for blending, morphing, transparency, perspective transformation, etc...
- Full support for UI skinning
- Graphics rasterization with OpenVG hardware
- Graphics UI elements created with Flash or SVG, exported to native OpenVG format
- Full font management provided by OpenVG 1.1
- 16X edge AA in HW
Web Browser

- A web browser implemented on top of i.MX35’s graphics hardware can take full advantage of the high graphics performance
  - A native browser application accessing the OpenVG API through the OS
- OpenVG 1.1 provides Flash and Font rendering acceleration, and a 2D bitmap engine accelerates the 2D elements of the browsing experience

- Browser window implemented with OpenVG provides smooth, non-sequential window resizing
- 2D element rasterization with 2D engine
- Clear and zoomable vectored fonts
- Flash acceleration for Flash elements
OpenVG Advantages: The User Experience

► Rich and responsive user interfaces
  • Today’s mobile devices have raised expectations

► Graphical user interface (GUI) acceleration
  • Dynamic Vector Font Rendering
  • Provides variety of advanced blending and drawing functions

► Great for Accelerating User Applications
  • Fast, scalable, skinnable user-interfaces
    ▪ Including animations and different aspect ratios

► Acceleration of Existing Content
  • Accelerates Flash Lite, Scalable VG, SVG Tiny
  • Web browsers: Opera, Netfront Access, Webkit, Mozilla
2D Applications

- **GPU-VGv1**
  - Low-power, high-performance OpenVG accelerator (licensed from ATI / AMD)

- **Complete hardware OpenVG 1.1 pipeline**
  - Both geometry and pixel processing
  - Adaptive processing of Bezier curves and strokes

- **Native Rendering of Vector Graphics Polygons**
  - No tessellation needed

- **Acceleration of Existing Content**
  - Accelerates Adobe Flash Lite, SVG Tiny, potentially Silverlight

- **Great for GUI Acceleration**
  - Dynamic Vector Font Rendering
  - Provides variety of advanced blending and drawing functions
  - Ultra-low-power mode for basic 2D blending

- **Great for Accelerating User Applications**
  - Fast, power-efficient, scalable, skinnable user-interfaces including animations and different aspect ratios
  - Web browsing
  - Navigation applications
    - Accurate map rendering at interactive frame rates
  - Cartoons, anime, greeting cards, games, mobile entertainment

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